Experimental estimates of UK quarterly greenhouse gas emissions (residence basis) QMI

Quality and Methodology Information for experimental estimates of UK quarterly greenhouse gas emissions, detailing methods used, data it provides, and strengths and limitations

Contact:
Gemma Thomas N, Oluwafisayo Alabi
environment.accounts@ons.gov.uk
+44 1633 560378

Release date:
25 July 2023

Next release:
To be announced

Table of contents

1 . Methodology background

- Experimental Statistics: Yes
- Frequency: Quarterly
- How compiled: Various sources and modelling
- Geographic coverage: UK

2 . About this Quality and Methodology Information report

This quality and methodology report contains information on the quality characteristics of the data (including the European Statistical System five dimensions of quality (PDF, 3MB)) and the methods used to create it.

The information in this report will help you to:

- understand the strengths and limitations of the data
- learn about existing uses and users of the data
- understand the methods used to create the data
- help you to decide suitable uses for the data
- reduce the risk of misusing data

3 . Important points

This report provides users of the experimental UK quarterly greenhouse gas (GHG) emission statistics on a residence basis, with information on their usability and fitness for purpose. These emissions estimates are produced using movements in higher-frequency indicators, known as predictor indicators, to split existing annual GHG emissions series into quarterly estimates. This process is known as temporal disaggregation. Given that these predictor indicators are more timely, they can be used to extrapolate the GHG emissions series forward, providing estimates for time periods beyond what is currently available. The annual GHG emissions estimates are usually published nine months after the end of the year, on a provisional basis, with final estimates available after 18 months. These experimental quarterly estimates are developed with the aim to increase alignment with the timeliness and frequency of UK GDP estimates.

The process for developing these experimental estimates has involved a series of research, knowledge exchange and stakeholder engagement activities. Our articles in May and December 2022 outline the challenges and complexities (for example, identifying appropriate predictor indicators) around producing these estimates, our proposed framework and potential future developments.

Our current method used for producing these experimental quarterly estimates of greenhouse gas emissions considers the residence-based estimates that the Office for National Statistics (ONS) produces. This is one of three measures of UK GHG emissions, from our Environmental Accounts. This measure is different from the UK territorial greenhouse gas emissions, published on GOV.UK, which are used to inform progress on UK-wide emissions targets. An article explaining these three UK emissions measures can be found on the UK Climate Change Statistics Portal: Measuring UK greenhouse gas emissions, on GOV.UK.

All estimates presented in the bulletin and accompanying dataset have been produced using modelling techniques and are therefore subject to uncertainty. See Section 6, Methods used to produce the quarterly estimates, for further information on the model, including the strengths and weaknesses.

4 . Quality summary

Overview

The main source of information for producing these experimental estimates are the UK annual estimates of greenhouse gas (GHG) emissions on a residence basis and the Energy Trends publication from Department for Energy Security and Net Zero, which provides information on UK energy production, consumption, and trade - for energy overall, and for specific fuels.

Annual GHG emissions on a residence basis are part of the UK Environmental Accounts. Details on the methodology used to calculated these, including associated uncertainty, can be found in our air emissions quality and methodology information. Any revisions to the annual emissions data will be reflected in any future modelled estimates.

The data from the latest quarter of Energy Trends used in the predictor indicators are provisional and are subject to revision. Any revisions to these data will be reflected in the modelled estimates. More details on the methodology used to construct energy trends data can be found on the relevant fuel pages of the Department for Energy Security and Net Zero's Energy Trends.

Uses and users

- Potential users of these estimates include international organisations, UK and other governments, National Statistical Institution (NSIs) and the research community.
- Because residence-based emissions estimates are produced on a comparable basis with the System of National Accounts, it is possible to derive figures for the intensity of GHG and CO2 emissions (that is, emissions per unit of economic output).

5 . Quality characteristics of the quarterly GHG emissions

Geography

These estimates are available at UK level. "UK level", in this context, is on a "residence" basis – that is, including activity of UK-registered businesses that may take place outside of the UK, and excluding activity in the UK of businesses that are registered abroad.

Coherence and comparability

As noted above, our estimates of UK greenhouse gas (GHG) emissions are one of three measures, alongside those published on a territorial and consumption or footprint basis.

Our residence-based estimates follow the UN System of Environmental Economic Accounting (SEEA). Estimates compiled on a residence basis include data relating to UK residents and UK-registered businesses regardless of whether they are in the UK or overseas. Emissions released in the UK by tourists and foreign transport operations are excluded. They also currently differ from territorial-basis emissions in that they include emissions associated with international shipping and aviation. The residency principle enables these GHG emissions estimates to be comparable with the National Accounts, including gross domestic product (GDP). This allows us to produce estimates of emission intensity at the economy level and industry level. It also provides insight into the relationship between the environment and economy.

Timeliness and punctuality

Published in our Atmospheric emissions: greenhouse gases by industry and gas dataset, greenhouse gas (GHG) emission estimates are currently produced annually around 18 months after the reference period. Our provisional estimates are published around nine months after the reference period. Residence-based GHG emissions have therefore not been available as quickly as territorial emissions and traditional economic indicators, such as GDP.

Concepts and definitions

The UN System of Environmental-Economic Accounting (SEEA), together with the UN System of National Accounts (SNA) and the European System of Accounts (ESA), provides a framework for producing internationally comparable statistics on the environment and its relationship with the economy.

6 . Methods used to produce the quarterly estimates

Temporal disaggregation and extrapolation

Our approach to produce these experimental quarterly greenhouse gas (GHG) emissions is underpinned by higher frequency modelling and statistical techniques developed using the Chow-Lin regression-based temporal disaggregation method. This involves temporal distribution and extrapolation, using higher-frequency predictor indicators to approximate the quarterly profile of emissions, where these predictors have a correlation with GHG emissions.

The temporal distribution process aims to preserve the within-year changes of these higher-frequency indicators as much as possible and is constrained to annual movements. However, to extrapolate beyond the last available year of annual emissions we use the quarter-to-quarter movements in the predictor indicators to extend our experimental estimates beyond that year, which inherently leads to a degree of uncertainty.

In comparison with our previous approach (Dec 2022), we use industry-level higher frequency predictor indicators that capture the quarter-on- quarter movement of emissions for a given industry or set of industries. Subsequently, these industry-level estimates are then used as input predictor indicators for more aggregated, top-level estimates (that is, total emissions). This approach introduces more details and interpretation to the within-year movement of GHG emissions.

One limitation of the current method is that it assumes a linear relationship between the predictor indicator and greenhouse gas emissions, meaning that it is constant over time. However, this is unlikely to be the case. For example, coal use may be a good predictor indicator for temporally disaggregating earlier years of emissions but would not be true in more recent years because of a shift to other fuels. Future methodological developments could involve allowing for changing relationships between emissions and predictor indicators over time within the modelling.

Choice of predictor indicators

There are several possible predictor indicators that may be used to derive these estimates. To identify the most appropriate indicators, through a series of knowledge exchange and stakeholder engagement activities, we reviewed the predictor indicators used by other National Statistical Institutions (NSIs) and international organisations. These included the IMF, the OECD, Statistics New Zealand and Eurostat.

Because the majority of GHG emissions are directly related to energy use, UK energy statistics can be used as a starting point for predictor indicators. Currently, all the predictor indicators used in our modelling are taken from the Department for Energy Security and Net Zero Energy Trends publication. These are published one quarter after the reference period, allowing us to estimate figures for UK greenhouse gas emissions for that time period. The provisional estimates for Quarter 1 (Jan to Mar) of 2023 were released in June 2023.

To utilise the available information on energy trends in the UK, we have focused on predictor indicators for the highest-emitting industries. These industries are, with shares of total GHG emissions on a residence basis in 2021:

- Agriculture, forestry, and fishing (9.5%)
- Manufacturing (16.9%)
- Electricity, gas, steam, and air conditioning supply industry (17.1%)
- Transport and storage industry (11.3%)
- Other (18.1%)

We also consider the predictor indicators for Household emissions (26.7%). Household emissions relate to emissions that fall outside of the production boundary. In the UK Environment Accounts, these emissions are split into consumer expenditure (non-travel) and consumer expenditure (travel). Consumer expenditure (non-travel) – emissions related to household heating and Consumer expenditure (travel) – emissions largely related to vehicle use, accounted for 14.9% and 11.8% of total greenhouse gas (GHG) emissions on residency basis in 2021, respectively.

Accuracy

These modelled estimates are classified as experimental statistics that include some uncertainty and should be used and treated with caution. As mentioned above, there is a time lag in the annual estimates of UK GHG emissions on residence basis, and figures for the latest year are provisional and subject to revision. The Energy Trends tables are available from Quarter 1 (Jan to Mar) 1998 to Quarter 1 (Jan to Mar) 2023 with the latest quarter in the series also being provisional.

The varying availability of input data means that the number of quarters being estimated varies depending on the publication date. Therefore, in the experimental estimates in the Bulletin and accompanying dataset for Quarter 1 (Jan to Mar) 2022 to Quarter 1 (Jan to Mar 2023), five quarters are modelled and derived by extrapolating and extending the series. This implies that the estimates for these periods are likely to be subject to a higher level of uncertainty. For the periods where provisional estimates are applied, this also introduces some uncertainty. However, this is a lower uncertainty level compared with the periods where a base or reference year is not available.

We undertook revisions analysis on all of the estimates to assess the likely scale of revisions. Because of the relatively short time series, it was not valid to summarise the revisions with descriptive statistics. However, to provide further insights around the level and implications of the uncertainties, we have also calculated forecast errors to provide an estimate of the reliability of the forecasted values.

Table 1: Predictor indicators used to derive these modelled estimates and level of accuracy of each model

Standard Industrial Classification (SIC)	Predictor	Target gas	Mean percentage error (MPE)	Mean absolute percentage error (MAPE)
C 19.2, C24, D, H49, H50, H51, 101	Manufacture of refined petroleum, Manufacture of basic metals, Energy, land transport, Water transport, Air transport, Household (excluding travel)	GHG	0.89	1.95
C24, D, H49, H50, H51, 101	Manufacture of basic metals, Energy, land transport, Water transport, Air transport, Household (excluding travel)	CO2	2.83	2.83
C24, D, H49, H50, H51	Manufacture of basic metals, Energy, land transport, Water transport, Air transport	GHG (excluding consumer expenditure)	0.44	1.86
C24, D, H49, H50, H51	Manufacture of basic metals, Energy, land transport, Water transport, Air transport	CO2 (excluding consumer expenditure)	0.88	1.58

Source: Environmental Accounts from the Office for National Statistics, Energy Trends from the Department for Net Zero and Energy Security

Notes

1. The mean percentage error (MPE) provides an estimate of a tendency (bias) to underestimate or overestimate.

2. The mean absolute percentage error (MAPE) provides an estimate of how accurate the forecast values are.

We calculated the mean percentage error (MPE) and mean absolute percentage error (MAPE) for the forecasts. The MPE provides an estimate of a tendency (bias) to underestimate or overestimate, and the MAPE provides an estimate of how accurate the forecast values are. In terms of the forecast accuracy, the model for total GHG emissions suggests that estimates for the latest year tend to be overestimated by 0.8% on average, and that the forecasts (in this case estimates for 2023) tend to be within a range between negative 1.9% to positive 1.9% of the final estimate.

The model for both GHG and carbon dioxide (CO2) emissions produced more reliable estimates compared with previous estimates, where top level (that is, total emissions) predictor indicators were applied.

These experimental estimates may be subject to revisions. More information is available on our Revisions policy page. Experimental estimates reported in this bulletin may therefore differ from previous publications. The revision process is complex and would be subject to the revision timeline of the various input data, review of the model, other methodological and future developments.

7 . Related links

Environmental accounts on air emissions quality and methodology information (QMI) article
Methodology | Last revised 4 July 2023
Quality and Methodology Information for air emissions in the UK Environmental Accounts, detailing the strengths and limitations of the data, methods used, and data uses and users.

Measuring UK greenhouse gas emissions article, available on the UK climate change statistics Portal
Article| Released 1 November 2021
Exploration and definitions of the three key official measures of UK GHG emissions, territorial, residence and footprint.

Department for Energy Security and Net Zero (DESNZ), Energy and Industrial Strategy (BEIS) Energy Trends publication
Data tables| Last updated 29 June 2023
Quarterly publication which presents data on the supply and demand of all the major fuels in the United Kingdom.

UK Environmental Accounts
Bulletin| Latest release 5 June 2023
How the environment contributes to the economy, the impact that the economy has on the environment, and how society responds to environmental issues. This page also hosts the development of natural capital accounts.

UN System of Environmental-Economic Accounting (SEEA)
Webpage
Introduces the System of Environmental-Economic Accounting (SEEA) and provides links to other related content.

8 . Cite this methodology

Office for National Statistics (ONS), released 25 July 2023, ONS website, methodology, Experimental estimates of UK quarterly greenhouse gas emissions (residence basis) QMI